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Strategic supplementation of multinutritional blocks for goats (*Capra hircus*) under an intensive system on the central coast of Peru

[*Suplementação estratégica de blocos multinutricionais para cabras (*Capra hircus*) em um sistema intensivo na costa central do Peru*]

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ABSTRACT

The objective of this study was to evaluate the effect of supplementation of multi nutritional blocks (MNB) for growing goats on their productive and economic performance in an intensive system, on the central Peruvian coast. For this, 51 Saanen goats at two months of age and 9.7±1.4kg live weight on average were randomly distributed in three treatments: T0 = control; T1 = MNB supplementation with 24% crude protein (CP), and T2 = MNB supplementation with 29% CP, for a period of two months. Initial live weight (ILW, kg), final live weight (FLW, kg), weight gain (WG, kg), survival rate (SR, %) and economic retribution (ER, S/) were evaluated, using SPSS v. 27. Values of 16.17±1.65 and 6.52±1.44kg were obtained for FLW and WG, respectively, and the SR was 100% for all groups. On the other hand, MNB supplementation had a highly significant effect (p = 0.000) on FLW and WG, and a higher SR was observed when MNB was supplied with 24% CP. In conclusion, MNB supplementation with 24% CP for growing goats, under an intensive production system, significantly improves their productive performance and would achieve a higher economic return.

Keywords: multinutritional block, goat, saanen, stabulation, Huaura

RESUMO

O objetivo deste estudo foi avaliar o efeito da suplementação de blocos nutricionais múltiplos (BNM) para cabras em crescimento sobre seu desempenho produtivo e econômico em um sistema intensivo, na costa central do Peru. Para isso, 51 cabras Saanen com dois meses de idade e 9,7±1,4 kg de peso vivo em média foram distribuídas aleatoriamente em três tratamentos: T0 = controle; T1 = suplementação de MNB com 24% de proteína bruta (PB) e T2 = suplementação de MNB com 29% de PB, por um período de dois meses. Foram avaliados o peso vivo inicial (PVI, kg), o peso vivo final (PVF, kg), o ganho de peso (GP, kg), a taxa de sobrevivência (RS, %) e a retribuição econômica (RE, S/), usando o SPSS v. 27. Foram obtidos valores de 16,17±1,65 e 6,52±1,44 kg para PPL e GP, respectivamente, e a RS foi de 100% para todos os grupos. Por outro lado, a suplementação com MNB teve um efeito altamente significativo (p = 0,000) sobre o FLW e o WG, e um SR mais alto foi observado quando o MNB foi fornecido com 24% de CP. Concluindo, a suplementação de MNB com 24% de PB para cabras em crescimento, em um sistema de produção intensivo, melhora significativamente seu desempenho produtivo e proporcionaria um maior retorno econômico.

Palavras-chave: bloco multinutricional, caprinos, saanen, estabulação, Huaura

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INTRODUCTION

Due to seasonal fluctuations in the availability of good quality forage (Fariñas *et al.*, 2009), it is not possible to meet the nutritional requirements of goat herds on a permanent basis. At the same time, poor utilization of locally available feed (Kachhawaha *et al*., 2022) has a negative impact on the needs of small ruminants for growth, gestation and lactation (Kawas, 2008).

On the other hand, in order to meet nutrient demands in ruminants, supplementation with concentrate feed could be uneconomical, especially when forage is of poor quality, highlighting the need for strategic supplementation (Mengistu and Hassen, 2017) with locally available feed resources (Noor *et al*., 2020; Sharma *et al*., 2004) for optimal ruminal function, so as to achieve a balance between fibrous feed degradation and energy intake for the animal (Rodriguez and Pulido, 2018), thus improving its productivity.

Based on the above, an alternative to minimize the negative impact due to lack of feed in critical periods, is the use of handmade multi nutritional blocks (MNB) (Fariñas *et al.*, 2009), which are considered supplements that can stimulate microbial activity in the rumen, which improves the digestion of poor-quality forage (Reshi *et al*., 2022), consumed by stabled or grazing ruminants (Rodríguez and Pulido, 2018). These authors also mention that the advantages of MNB, as opposed to flour or liquid supplements, include ease of handling and transport, having a more homogeneous consumption by the animals, the reduction of the need for salt as a consumption regulator and, at the same time, a lower risk in urea as a non-protein nitrogen contributor.

Unfortunately, in Peru, there are few studies on the goat species, and none referred to strategic supplementation; therefore, it is necessary to evaluate the impact of strategic supplementation with MNB in goats, and specifically in the growth stage, as it is critical and the one that ensures future productive and reproductive performance (Zamuner *et al.*, 2023). Therefore, the objective of this study was to evaluate the effect of MNB supplementation for growing goats on their productive and economic performance in an intensive production system located in the province of Huaura, department of Lima, Peru.

METHODOLOGY

The research was carried out at Agropecuaria Duman SAC, located in the Centro Poblado Huacan of the Santa María district (75 masl, 11°05′30″S 77°34′23″W), Huaura province, Lima department - Peru (Fig. 1). This district is characterized by a warm spring climate throughout the year, with temperatures ranging from 12 to 28°C, with light annual rainfall from 7 to 50 mm (Fuerza Regional, 2018). Similarly, The Duman company is characterized by its intensive dairy production system, with a predominance of specialized breeds. Specifically for the experiment, three pens were conditioned together with an area of 21 m^2 each.

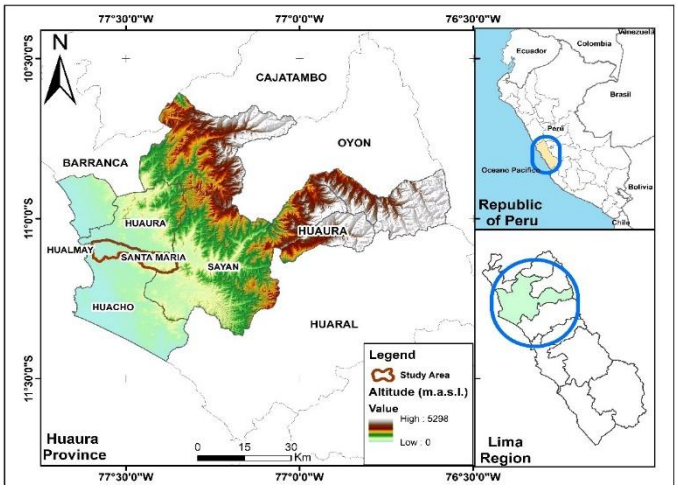

Figure 1. Geographic location of the area where the study was conducted.

51 two month old Saanen goats, clinically healthy and with an average live weight of 9.7 ± 1.4 kg, were distributed equally and randomly to one of three treatment levels: T0 = Control, T1 = MNB supplementation with 24 % CP, T2 = MNB supplementation with 29 % CP; for a period of two months. Once the experiment was started, the MNB was supplied depending on the time they were consumed in each pen. On the other hand, the weighing of both the MNB residue and the animals was carried out weekly; finally, the supply of water and balanced concentrate feed was *ad libitum*.

The MNB used were previously evaluated considering their nutritional content, ease of preparation and physical consistency. Table 1 shows the inputs, percentages used and nutritional composition of both MNB.

Table 1. Characteristics of the MNBs used in the experiment.

a) MNB 24 % CP		b) MNB 29 % CP	
Input	%	Input	%
Premix vit/min	4.00	Premix vit/min	3.0
Bran	8.00	Bran	3.0
Whole soybean flour	20.00	Whole soybean flour	17.0
Cane molasses	36.00	Cane molasses	35.0
Soybean meal	16.00	Soybean meal	28.0
Ground corn	8.00	Ground corn	7.0
Cement dust	8.00	Cement dust	7.0
Total	100.0	Total	100.0
Nutritional Composition (%)			
Dry Matter	86.95	Dry Matter	84.13
Crude Protein	24.12	Crude Protein	29.24
Ether Extract	2.04	Ether Extract	1.84
Crude Fiber	1.70	Crude Fiber	2.05
Ash	21.92	Ash	22.45

It is worth mentioning that the nutritional composition was obtained by means of a proximal chemical analysis performed on both MNB at the Laboratory of Biochemistry, Nutrition and Animal Feeding of the Faculty of Veterinary Medicine of the Universidad Nacional Mayor de San Marcos, to contrast the nutritional content of the software used to formulate and the real one. Likewise, the elaboration and obtaining of the MNB had a duration of one week, considering the processes of preparation, setting, demolding and drying (Tobia and Vargas, 2013), as shown in Fig. 2.

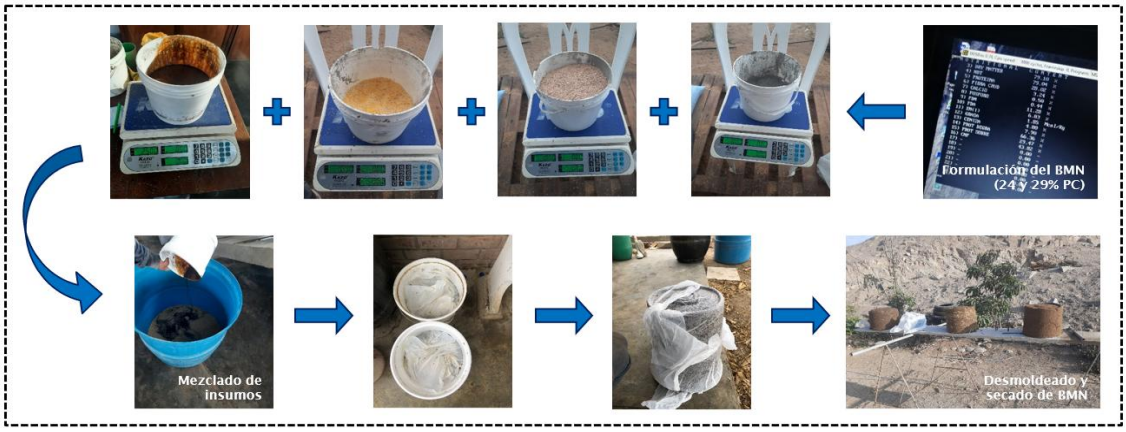

Figure 2. MNB elaboration process.

The following parameters were recorded:
Initial live weight (ILW, in kg) = weight at the beginning of the experiment.
Final live weight (FLW, in kg) = weight at 56 days of the experiment.
Weight gain (WG, in kg) = final live weight - initial live weight.
Survival rate (SR, in

$$\%) = \left(1 - \frac{goats\ dead\ \ during\ the\ experiment}{total\ number\ of\ goats\ at\ the\ beginning\ of\ the\ experiment}\right) x\ 100$$

Economic retribution (ER, in S/) = income (value of the carcass) - expenditure (value of MNB supplementation).

A completely randomized design was used, with three treatments and 17 experimental units (goats) per treatment. For this, the mathematical model was as follows: $Y_{ij} = \mu + ILW_i + MNB_j + e_{ij}$, where, Y_{ij} = observed response variable (FLW and WG), μ = overall mean for FLW and WG, ILW_i = effect of covariate ILW, MNB_j = effect of MNB supplementation, e_{ij} = random error associated with each observation. It is worth mentioning that, once the fulfillment of all assumptions was verified, an analysis of covariance was performed to determine significant differences for FLW and WG, both corrected for the covariate ILW. This was done with the support of SPSS Statistics version 27.

RESULTS AND DISCUSSION

The main statistical measures for the parameters evaluated in this study are shown in Table 2. In this sense, it is evident that the FLW of growing goats is more homogeneous and reliable than their WG, because it presents a much lower V.C. (Pimentel, 1985; Patel *et al.*, 2001; Gordón-Mendoza and Camargo-Buitrago, 2015).

When doing the variance analysis, considering ILW as a covariable, showed a highly significant effect of MNB supplementation on FLW of growing goats (p = 0.000), as shown in Table 3.

Table 2. Descriptive statistics of the productive parameters evaluated in growing goats at Agropecuaria Duman (n = 51)

Evaluated parameters	Average	E.D.	V.C.	Min.	Max.
Final live weight, Kg.	16.17	1.65	10.19	13.4	19.9
Weight gain, Kg.	6.52	1.44	22.12	4.0	9.3

Table 3. Effect of MNB supplementation on final live weight of growing goats at Agropecuaria Duman[1,2,3]

MNB Supplementation	Final Weight in kg. ($\bar{x}$ ± e.e.)	p	Confidence Interval at 95% (L.I – L.S.)
T0 = Control.	14.76 ± 0.21 [b]	0.000	14.33 - 15.19
T1: MNB with 24% CP.	17.26 ± 0.21 [a]		16.84 - 17.69
T2: MNB with 29% CP.	16.50 ± 0.21 [a]		16.07 - 16.92

[1]Different super-indexes within the same column indicate significant differences (p<0.05).
[2]The FLWs shown are adjusted for the ILW covariable.
[3]R^2 = 73.6 %.

Similarly, a highly significant effect of MNB supplementation on WG (p = 0.000) was evident, as shown in Table 4.

The results of the present investigation agree with what has been reported in the literature. Such that, Panadi *et al.* (2018a) compared supplementation of molasses and urea based MNB, medicated (0.05% fenbendazole with 32.84% CP) and non-medicated (33.84% CP), with commercial mineral blocks (CP not determined) and a basal diet consisting of pasture (15.54% CP), and commercial pellet feed (17. 13% CP), in lactating Saanen goats from the Kelantan region in Malaysia, concluding that both medicated and non-medicated MNB supplementation were effective in improving appetite, dry matter intake, milk production, daily weight gain and minimizing weight loss during lactation in goats. On the other hand, MNB supplementation was also effective in controlling parasite infestation in dairy goats, in addition to improving their hematological parameters (Panadi *et al*., 2018b). Similarly, Panadi *et al*. (2019) showed that MNB supplementation was effective in improving the blood mineral profile of goats. The above evidences the need that MNB supplemented in goats must contain high levels of CP, for its effects to be significant on health of goats, which is the producer's main priority, according to a survey carried out by Anzuino *et al.* (2019).

Table 4. Effect of MNB supplementation on weight gain of growing goats at Agropecuaria Duman.[1,2,3]

MNB Supplementation	Weight gain in kg. ($\bar{x}$ ± e.e.)	p	Confidence Interval al 95% (L.I – L.S.)
T0 = Control.	5.11 ± 0.21 [b]		4.68 – 5.54
T1: MNB with 24% CP.	7.61 ± 0.21 [a]	0.000	7.19 – 8.04
T2: MNB with 29% CP.	6.85 ± 0.21 [a]		6.42 – 7.27

[1]Different super-indexes within the same column indicate significant differences. (p<0.05).
[2] The WGs shown are adjusted for the covariable ILW.
[3] R^2 = 65.6 %.

Noor *et al*. (2020) evaluated the effect of supplementing medicated and non-medicated MNB on milk composition and milk quality of Saanen goats for 90 days on a farm in Malaysia, finding that milk production and milk quality were significantly higher when animals received both types of MNB.

Likewise, Manuel-Luviano *et al*. (2018) evaluated the feeding behavior of Boer and Creole goats consuming MNB, with local raw material and replacing sugarcane molasses with mango pulp. For this purpose, they elaborated 4 MNB with different levels of inclusion of hand pulp and when performing the bromatological analysis, these contained from 31.51 to 36.16% CP. It is worth noting that the authors observed no differences between the different experimental groups with respect to the feeding behavior of goats in the tropics of Guerrero, Mexico.

Araujo *et al*. (2017) conducted an experiment in this regard in the semi-arid region of Paraíba state - Brazil, concluding that uncastrated lambs and goats supplemented with MNB improved their final weight, yield of commercial cuts, greater musculature (in goats) and greater adiposity in the carcass (in lambs). Zavala (2002) developed MNB to supplement goats in grazing and in times of drought, to reduce its negative impact. These blocks were made up of molasses, urea, salt, lime, cement, flourolin and bran, weighed 20 kg and contained 40.80% CP. According to the results, the animals that consumed MNB reported a higher consumption of dry forage, a reduction in abortions and a higher number of offspring. Sánchez and García (2001) evaluated the effect of MNB supplementation on live weight variation and abortion rate in goats under traditional production systems in the arid zone of Siquisique - Venezuela, concluding that it is an excellent

alternative to improve the productive and reproductive parameters of goats.

In another study, Navarro *et al*. (2020) determined the nutritive value of the residue (both peel and pulp/peel mixture) of mango and avocado fruits to evaluate the possibility of using them in the preparation of MNB, concluding that a mixture of pulp and peel in the formulation of MNB for goat feed is feasible and contributes to the reduction of the environmental impact of these wastes. However, they suggest further studies to evaluate the acceptability and digestibility of these MNB, as well as their stability over long storage periods.

Singh *et al.* (2015) determined that when goats, experimentally infected with *Haemonchus contortus*, were supplemented with MNB, they significantly increased their hemoglobin levels and reduced fecal egg counts, thus suggesting the use of MNB as a sustainable alternative method to control parasitosis.

It is worth mentioning that, MNB have many attributes: as its name says, they are multinutritional, since they contain high levels of protein, energy, phosphorus among others; it is useful for all domestic ruminants; useful in any production system; easy to store and transport by any means; its distribution is simple (just protect it from soil and animal trampling); its use is safe, since a well-formulated MNB reduces the risk of toxicity and acidosis in the ruminant; its consumption is limited; there is no competition among cattle to consume it; improve production and reproduction and therefore, the profitability of the establishment (Gutiérrez and Ayala-Burgos, 2016).

It is important to note that, in this research, it was decided not to use urea, since it is a toxic input if used in large quantities for animal feed. Likewise, high levels of protein in the diet result in high levels of urea in the blood (Acuña, 2020) and this probably explains why the goats supplemented with a MNB of 29% CP presented lower FLW and WG at the end of the experiment, compared to those that consumed the MNB of 24% CP.

This is because when there is more protein than energy in the diet, an imbalance is generated at the rumen level, since the microbial flora cannot continue to increase due to lack of energy, so it will be forced to use protein as a source of energy and in this process, ammonia is released. Considering that the hepatic detoxification of excess ammonia coming from the rumen requires a caloric expenditure for ruminants (Garriz and López, 2002), this means that there will be less energy input for the various physiological activities such as growth, production and/or reproduction.

Similar results to the present one have also been observed in other domestic ruminants. Kachhawaha *et al*. (2022) developed a MNB in arid Rajasthan of India for supplementation of lactating buffaloes for three months and observed that, milk production, milk fat percentage, general health status and reproductive performance improved significantly in females consuming this MNB, thus suggesting MNB supplementation when forage is of poor quality. Acuña (2020) evaluated the effect of supplementation with MNB based on agro-industrial by-products for Brown Swiss mestizo bulls in the Amazon region of Peru and observed that MNB (from 32.0 to 34.2% CP) improved weight gain and body condition. Yerima *et al*. (2020) evaluated the effect of supplementing MNB with different levels of urea on growth in Yankasa lambs in Nigeria and found higher weight gains and better feed conversions in animals consuming MNB with 10% urea. Vásquez-Mendoza *et al*. (2012) evaluated the effect of MNB supplementation on the productive behavior of sheep in confinement and grazing in the southern region of Mexico, concluding that MNB improved daily weight gain of sheep in both production systems.

However, other studies such as that of Godoy *et al*. (2020), who evaluated the effect of MNB based on agro-industrial residues on the quantity and quality of milk produced by cows in the Peruvian tropics, found no statistical differences, possibly due to the low consumption of MNB by the animals.

During the experimental phase of the study, no sick animals were recorded and, therefore, there was no mortality in any of the three groups.

The economic return obtained from MNB supplementation in growing goats at Agropecuaria Duman is shown in Table 5.

Table 5. Effect of MNB supplementation on economic returns of growing goats at Agropecuaria Duman

Evaluated Parameters	MNB Supplementation		
	T0 (Control)	T1 (MNB 24% CP)	T2 (MNB 29% CP)
Final Live Weight (kg)	14.76	17.26	16.50
Carcass Performance (%)	50.0	50.0	50.0
Carcass Weight (kg)	7.38	8.63	8.25
INCOME:			
Price per kg. of carcass (S/)	15	15	15
Total Income (S/)	110.70	129.45	123.75
EXPENSES:			
MNB Consumption (kg)	-	6.50	7.82
Price per kg. of MNB (S/)	-	2.25	2.29
Total Cost(S/)	-	14.63	17.91
ECONOMIC RETRIBUTION:			
Absolute (S/)	110.70	114.82	105.84
Relative (%)	100.0	103.7	95.61

According to the table above, the group of goats that were supplemented with MNB of 24% CP presented the highest economic return, with an economic return of S/ 114.82, which represents 103.7%, compared to the economic return obtained with the group of goats that did not receive any MNB supplementation. It is worth mentioning that previous studies on this species were only limited to a productive evaluation (Zamuner *et al.*, 2023), while the present study carried out a technical-economic evaluation. These results are similar to those reported by Yerima *et al*. (2020), who determined that MNB supplementation with 10% urea for Yankasa lambs in Nigeria achieved higher growth rates and, therefore, a significant reduction in the cost of supplementation; and by Farias *et al.* (2019), who evaluated MNB supplementation in lactating goats and found that the use of low levels of concentrate associated with MNB is the best economic feeding strategy for this category.

There is no doubt that supplementation strategies for goats consuming poor quality forages, whether grazing or stall-fed, must be designed to synchronize the degradability of proteins and carbohydrates in the rumen and thus increase the passage of nutrients to the small intestine for absorption (Kawas, 2008). In this sense, the development and use of MNB for goat kids in different production systems in our country is a strategy to be considered, especially when it can have long-term effects and impact productive performance and health (Zamuner *et al.*, 2023).

CONCLUSIONS

MNB supplementation for growing goats, under an intensive production system in the central coast of Peru, had a positive and highly significant effect on final live weight and weight gain. Specifically, MNB supplementation with 24 % CP had the highest economic return.

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